The NASA "Why?" Files The Case of the Challenging Flight

Segment 4

The day of the contest is fast approaching, and as the tree house detectives review all they have learned, they feel confident about their entry into the contest. The modifications they have made to their plane have brought major improvement to their plane's flight capabilities. To bring it all together, the tree house detectives visit a Young Eagle's pilot who gives them a flying lesson. With their knowledge of flight, a modified plane, and a little luck, the tree house detectives are ready to thrust forward into aviation's hall of fame as the winners of the Egg-tra-ordinary Plane Contest!

Objectives

Students will

- learn the function of rudders and elevators on an airplane.
- learn how synthetic vision will help pilots of the future.

Vocabulary

cockpit - control center housing pilot, instrumentation, and navigational aids used in flying

elevator - surface on the horizontal part of the tail section that moves up or down to assist the aircraft in maintaining level flight and adjusting the pitch of the aircraft

engine - part of the aircraft that provides the power for takeoff and landing, and sustains flight

synthetic vision - system developed by NASA Langley Research Center in Hampton, Virginia, that uses satellite signals and global positioning systems to give a pilot an electronic picture that is an exact duplication of the physical terrain, including man-made structures. This system will enable pilots to fly in environments that have limited visibility, thus saving lives.

yoke - control device in the cockpit used to maneuver the plane that looks similar to a car steering wheel, which is used to maneuver the plane

Video Component (15 min)

Before Viewing

- 1. Briefly summarize the events in Segment 3.
- 2. Discuss what the tree house detectives have investigated thus far and ask students if there is anything remaining that needs to be investigated.
- 3. Predict the outcome of the contest.

After Viewing

- 1. Continue working with the display board to reinforce the investigation steps that the tree house detectives took to solve the problem.
- 2. Choose from the activities in this packet and on the web site to reinforce the concepts being emphasized.
- 3. List safety concerns pilots and airports must consider when planes are flying in poor weather conditions. Discuss how aircraft technology has changed to make flying safer.
- 4. Compare and contrast how helicopters and airplanes fly.
- 5. Discuss how aviation has affected the movement of people and materials in history.
- 6. List the many jobs and careers that were created by the industry of flight.

Resources

Books

Grant, Donald, Nancy Krulik, and Gallimard Jeunesse: Airplanes and Flying Machines. Scholastic, Inc., (1992) ISBN: 0590452673

Hsu, Gery: How to Make Origami Airplanes That Fly. Dover Publications, Inc., (1992) SBN: 0486273520

Publications

Aeronautics: An Educator's Guide with Activities in Science, Mathematics, and Technology Education is available in electronic format through NASA Spacelink, http://spacelink.nasa.gov/products or can be obtained from your local Educator's Resource Center.

Videos

Milestones of Flight was produced by the National Air and Space Museum and is based on the museum's "Milestones of Flight" gallery. The video traces the history of flight from Langley's first attempts to the space shuttle.

Transformation of Flight is an animated video produced by the Smithsonian Institution that presents ten important air and spacecraft events in the history of flight from the Wright Brothers' first flight to the space shuttle program.

Web Sites

Young Eagles Program

Get involved in the Young Eagles Program and help EAA (Experimental Aircraft Association) reach their goal of taking one million young people on an airplane ride. Locate the chapter nearest you. http://www.eaa.org/youth/youngeagles.html

Regional Educator Resource Centers (RERCs)

RERCs offer educators access to NASA educational materials. A complete list of RERCs is available electronically via NASA Spacelink. http://spacelink.nasa.gov/ercn/

The Earth to Orbit Program

Connects students with the work of NASA engineers by engaging them in related design challenges in their own classrooms. With some simple and inexpensive materials, students can participate in an exciting learning experience...the challenges of designing the next generation of space vehicles. http://eto.nasa.gov/

Flight Testing Newton's Laws

Aircraft are used to stimulate the student's interest in the physical sciences and mathematics. An explanation of Newton's Laws of Motion is offered for both students and teachers, along with an aeronautics guide for grades K-4. Information is also available on how to obtain copies of the videos for "Flight Testing Newton's Laws" from Dryden Flight Research Center. http://trc.dfrc.nasa.gov/trc/index.html

Careers

researcher flight instructor

Activities and Worksheets

contest

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In the Guide | Anatomy of an Airplane57

Use definitions to label the parts of an airplane

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Four Forces of Flight Game 61Use the four forces of flight to help you be the first to reach Liftville airport

Rescue at Sea Game64

Use the four forces of flight, probability, and coordinate pairs to rescue a stranded man on a deserted island

The Egg-tra-ordinary Airplane**68**Construct a model of the plane featured in the video to have your own Egg-tra-ordinary plane

On the Web

You can find the following activities on the Web at http://whyfiles.larc.nasa.gov.

Battle of the Airplanes

Using the Internet, compare various airplanes.

Anatomy of an Airplane

Use the definitions below to label the parts of the airplane.

ailerons - surfaces on the outer edge of a wing that move up and down

cockpit - control center where pilot, instrumentation, and navigational aids used in flying are located

elevator - surface on the horizontal part of the tail section that moves up or down to assist the aircraft in maintaining level flight and adjusting the pitch of the aircraft

elevon - an airplane control surface that combines the functions of elevator and aileron

engine - part of the aircraft that provides the power for takeoff and landing and sustains flight

flaps - retractable trailing edges of a wings that move down to increase wing surface and increase lift on take-off. Located closer to the fuselage than the aileron.

fuselage - body of an airplane, excluding the wing and tail section

landing gear - wheels or floats of an aircraft

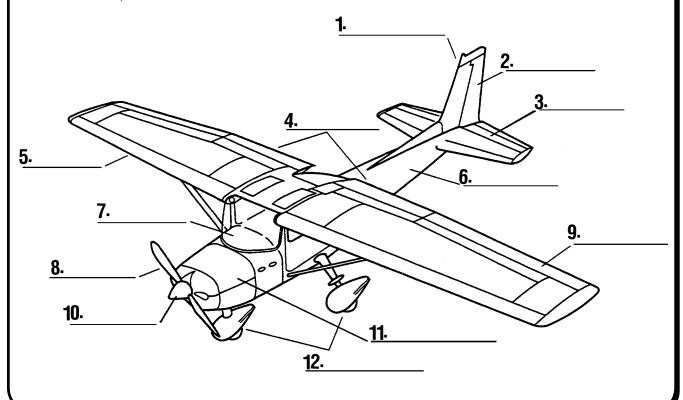
propeller - twisted airfoil, or turning blade, powered by the engine and providing thrust

rudder - vertical part of the tail section that moves left or right to stabilize the aircraft during crosswind takeoff and landing or in severe wind conditions

spinner - part of the shaft that covers the center of the propeller and helps smooth the airflow over the engine

tail section - section of the plane housing the elevator, stabilizer, fin, and rudder

wing - an airplane's airfoil, producing lift as the craft moves through the air. It has two movable controls: ailerons and flaps.



Aileron or No Aileron

Purpose

To learn how ailerons affect flight patterns. To learn how to collect, organize, display, and interpret data.

Procedure

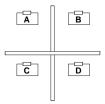


Diagram 1

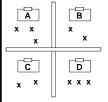


Diagram 2

1. Using the glider template (p. 60), trace and cut out glider.

- 2. Carefully cut a slot in the fuselage, following the guide on the template, and slide the wing into it.
- 3. Mark the dotted lines for the ailerons and the rudder, but do not bend at this time.
- 4. In a large, enclosed area such as a hallway, place a piece of tape on the floor, creating a start line for each group.
- 5. Measure 2.5 m from each start line and make this the center of the grid.
- 6. To make the grid, lay two pieces of tape, each 1 m long and perpendicular to each other.

Materials (per group)

masking tape or duct tape

heavy construction paper or foam

glider template

science journal

meter stick

crayons

4 index cards

large enclosed area

scissors

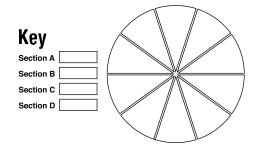
- 7. Using index cards, mark the top left grid as section A, top right grid as section B, bottom left grid as section C, and bottom right grid as section D. Tape them in place. See diagram 1.
- 8. Draw grid in the science journal.
- 9. Aim at the center of the grid and throw the airplane. Using an "X," mark in the science journal the actual grid that the plane landed in. See diagram 2.
- 10. Repeat for a total of ten trials.
- 11. Answer the following questions:

Which section of the target did the plane hit the most? The least? How many landings were in section A? Section B? Section C? Section D? Write a fraction to express the number of landings in each section. Write a decimal for each of these fractions.

12. Following the sample section, organize your data in the table below.

Area	No. of Landings	Total Flights	Fraction	Decimal	Equation
Sample Sec.	4	10	4/10	0.4	4/10 = 0.4
Section A					
Section B					
Section C					
Section D					

13. Using the information from the table, create a circle graph below. Use a different color for each section.



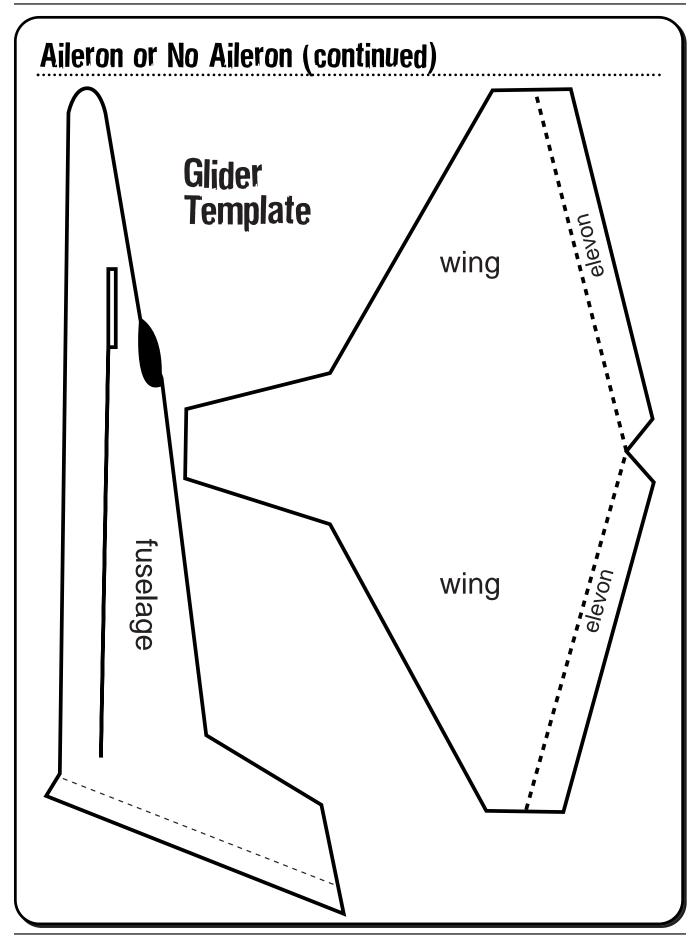
Aileron or No Aileron (continued)

- 14. Discuss and analyze the data.
- 15. Discuss the purpose of ailerons and rudders on airplanes.
- 16. Predict how the landing patterns will change when the ailerons are bent.
- 17. Bend and fold the ailerons on the wing so that one aileron is bent up and one is bent down. Repeat steps 8-13.
- 18. Predict how the landing patterns will change when the rudder is bent.
- 19. Bend and fold the rudder on the tail and repeat steps 8-13.

Conclusion

- 1. What effect, if any, did the ailerons have on the landing patterns?
- 2. What effect, if any, did the rudder have on the landing patterns?
- 3. Explain any similarities or differences in your graphs.
- 4. Using the graphs, what conclusions can be made about how ailerons affected the direction of the planes?
- 5. What happens when air hits the ailerons? How would pilots use ailerons on real planes?

- **Extensions** 1. Test various designs of paper airplanes.
 - 2. Test various positions of the ailerons and rudders.



Four Forces of Flight Game

Purpose

To have experience with the positive and negative forces of the four forces of flight.

Game

Objective

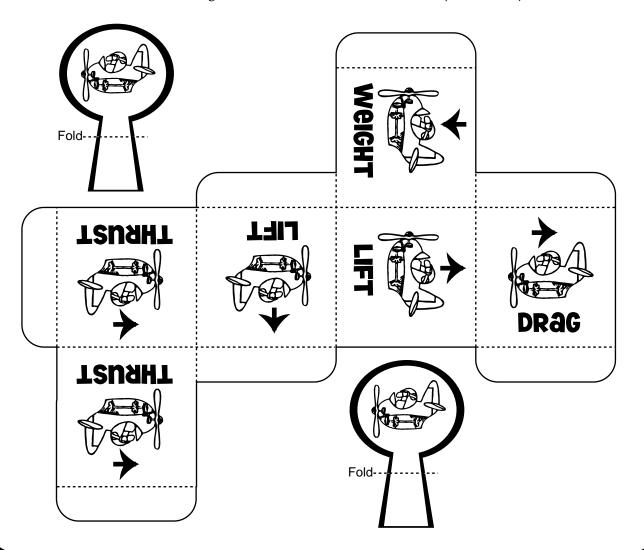
To be the first to arrive at Liftville Airport after departing from Thrust City Airport.

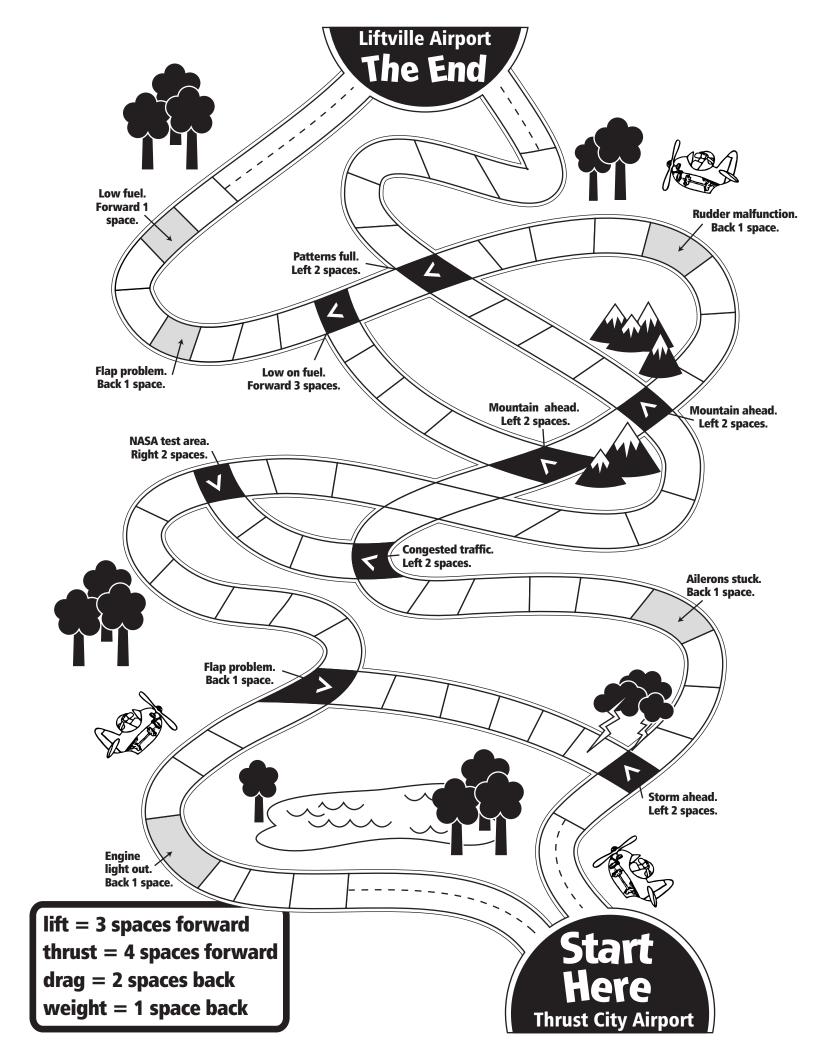
Materials

game board game pieces game cube

Procedure

- 1. The player whose birthday is closest to January 1 will be the player to start the game. The player with the next closest birthday will go second and so on.
- 2. To make the game cube, cut along solid lines and fold along dotted lines. Glue or tape tabs to the inside to form a cube.
- 3. Starting at Thrust City Airport, choose a runway for takeoff and roll the cube.
- 4. Move your airplane the number of spaces indicated.
- 5. The next player will now take his turn and so on.
- 6. If you land on a space that indicates a "problem," follow the directions given on that space.
- 7. Continue taking turns until a winner reaches Liftville Airport's runway.





Flying Word Search

Locate the key vocabulary terms in the word search below.

```
aerodynamic
                                    landing gear
                                                       tail
                  jet
                                                       lift
aileron
                                    wind tunnel
                  engine
airplane
                  flight
                                    pilot
                                                       pitch
airport
                  control tower
                                    runway
                                                       thrust
                  fuel
                                                       wings
cockpit
                                    weight
```

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ETABAYUB
   NAILZAZNA
   IJXWMSQINO
   GEOLIATPWIC
   NTCBSHKTXHD
   ELANDINGGEAR
   FLIGHTCKHFMD
   CGNVGMLAWMASS
   CABZUREWOTLORTNOCPITCH
   IRLENNUTDNIWKNJTTROPRIA
L
Q I N M D V D T M O I W X W N X N U F Y F M P Q C V Y
HEUATMNFCJYFKMHCDDIAATT
HGHNEXHHOSUYHRXJYALLICTEG
DJPYBENQCYJNPJXRJPUNRTHGIEWWHR
   DXNPMKLKSLPFQWGZGPTYMYMHIQZ
   O E A D C P C F S E H K A G E Y S L Y C U W T S N M W
   RFLRBICRFIKWBLZUHANBPKYBGST
AASELPEJTLEUFFPJWYQVNZHJPVVSF
TSHAINTRTCCRHDLOQJWJETOLIPL
TDPJGOSRIOGJKGOGCSLGHBCUXG
EXKMHRUFOBSMJPUR
R
   NTERMUVAABNU
   MCLHRSCQWFVC
   YRITSIDBCIX
   AEAIOWHKASK
   WWXCJEFRIA
   NVWYRDPTRB
   UNURGSZIL
   RSREWQBLK
   KYXULBNZ
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Rescue at Sea Game

Purpose

To identify the positive and negative values of the four forces of flight. To collect, organize, and interpret data. To determine probability. To read, write, and plot ordered pairs on a grid.

Procedure

Diagram 1

is on p. 65.

- 1. Make a transparency of Diagram 1 (p. 65), and use it to review the four forces of flight. Point out that the arrows show the direction associated with each of the four forces.
- 2. Explain to the students that they will be playing a rescue at sea game and distribute a copy of the gameboard (p. 67) to each group.

3. Read the following mission to the students: The USS Theodore Roosevelt has just received a distress call. A person is stranded at the top of a mountain on an island that is close to the ship's location. Due to an approaching storm, you must quickly launch your helicopter and fly to the island to rescue the person.

Materials (per group)

coordinate grid chart

spinners A, B, C, and D

paper clip

pencil

crayons

science journal

- 4. Pass out the spinners (p. 66), and explain how the spinners determine the direction to move in the game. Lift (up one space), drag (left one space), thrust (right one space), and gravity/weight (down one space).
- 5. Ask the students to look at the game board and determine which direction they will need to fly to rescue the stranded person.
- 6. Review the spinners. How are they alike? Different? Have students predict which spinner will be the most helpful in their mission and why.
- 7. To test their predictions, spin each spinner 50 times and record the results in a tally table. Compile data into a bar graph. Note: To create a "spinner," have the students use a pencil point to hold a paper clip in the center of the circle and then spin the paper clip. See diagram 2.

Diagram 2

- 8. Compare the results of the spinners and discuss each spinner's probability for the forces they will need the most in their mission (lift and thrust). Discuss the advantages and disadvantages of using each spinner. Have the students save their data and graphs to use during the game to help them choose a spinner to use for each turn.
- 9. Review ordered pairs and how to read, write, and plot points on a coordinate grid.
- 10. Ask students to predict how many spins it will take to reach the top of the mountain.
- 11. Using the example below, have the students create a table in their science journals to record their data.

Turn	Spinner	Pointer	Direction	Coordinate	
Number	Selected	Landed On	Moved	Landed On	
Ex.: 1	ס	Lift	Up	0, 1	

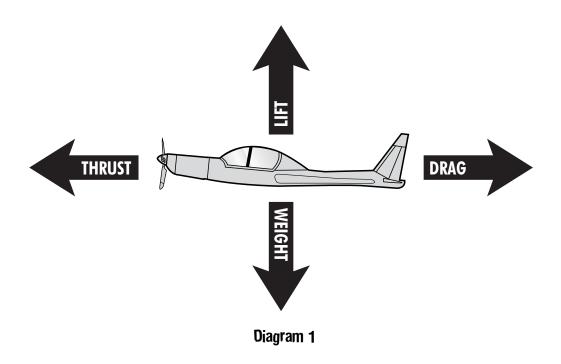
- 12. Have the students choose a spinner, spin, and record data in the chart.
- 13. To plot their coordinates on the grid, have the students use a different color for each pilot. Remind students to color in the key on the coordinate grid chart.
- 14. Have the students continue playing the game, taking turns and choosing spinners. The first pilot to reach the stranded person on top of the mountain wins the game.

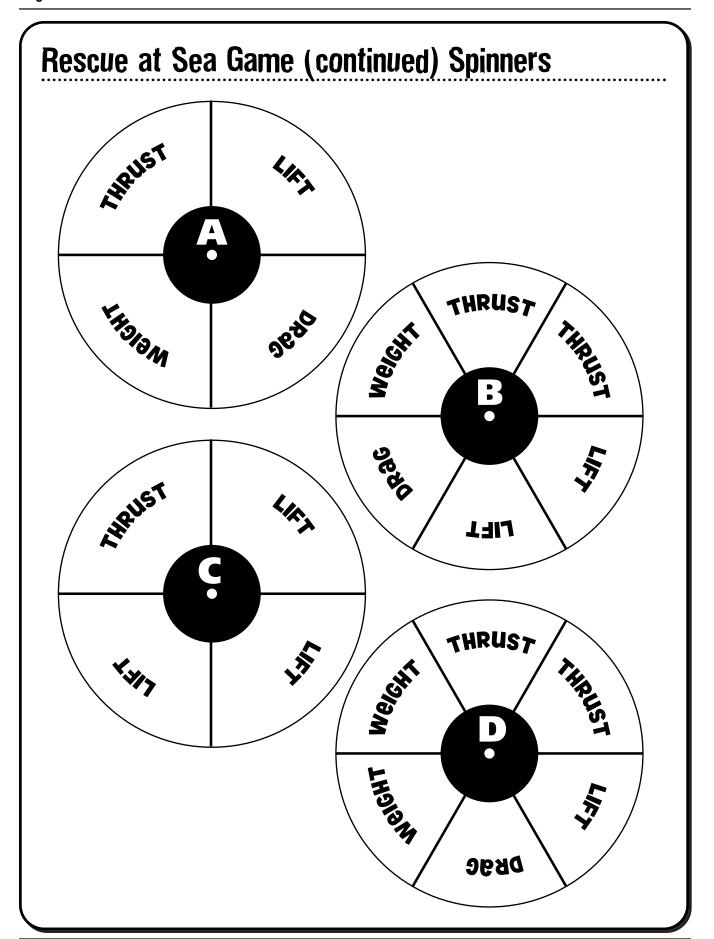
Rescue at Sea Game (continued)

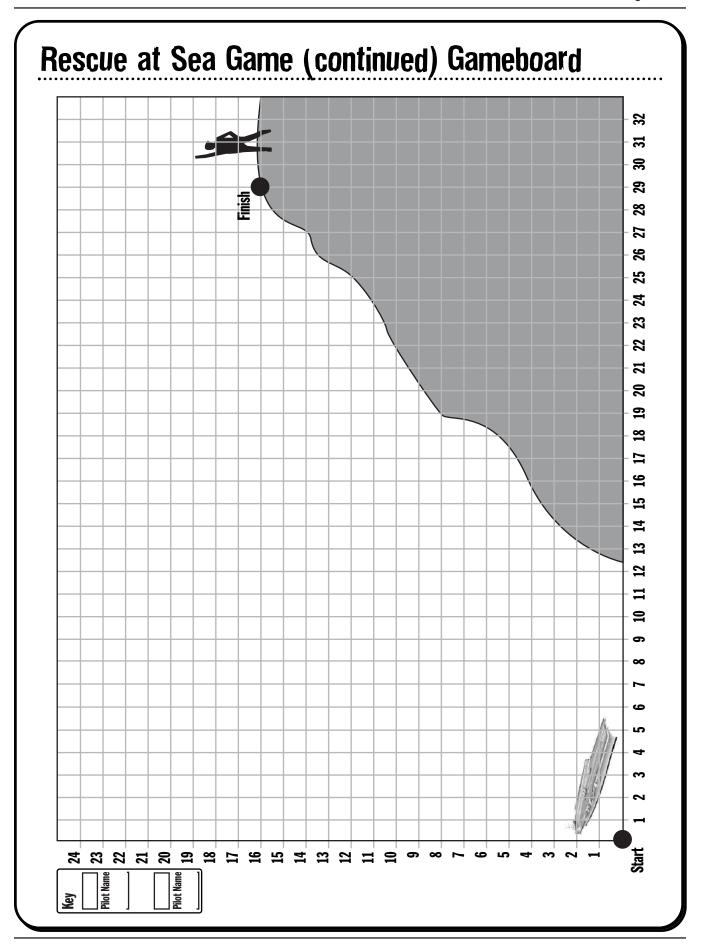
Conclusion

- 1. How did your predictions compare with the number of spins it actually took to reach the top of the mountain?
- 2. How did the spinner's probability information help you determine which spinner to use for each turn?
- 3. Using the coordinate graph chart, how did your flight path compare to your partner's? Explain why they were the same or different.

- **Extensions** 1. Add fuel consumption to the problem. For example, give the students a limited number of gallons of fuel and have each space represent a certain number of gallons of fuel used for each turn. Have students predict the number of gallons they will need for the mission.
 - 2. Make a new game board that favors a different spinner.
 - 3. Make new spinners that would best suit the game.
 - 4. For advanced students, create a game board that would involve positive and negative integers and that would extend into other quadrants of the coordinate plane.







The Egg-tra-ordinary Airplane

Purpose

To construct a model of the plane featured in the video. To use knowledge of the four forces of flight to modify the plane.

Procedure

- 1. Cut the wing from the 12-egg carton as shown, using scissors. (If razor blade or knife is used, adult help is required.)
- 2. Notch the center of the wing so that it fits snuggly over the balsa wood, but do not glue. See diagram 1.
- 3. Use the ruler as a guide to bend the egg carton into a dihedral angle into the wing. Repeat twice on each half of the wing. See diagram 2. Note: If the wing cracks on the underside, rub glue into the cracks and let dry.
- 4. Using the template (p. 69), cut out the stabilizer and fin pattern and trace them onto the inside of the 18egg carton top.
- 5. Cut out the stabilizer and fin.
- 6. On the side of the fuselage stick (balsa wood), mark the locations of the wing and the pin that will hold the rubber band.
- 7. To save weight in the tail of the model, trim off excess wood behind the pin. See diagram 3.
- 8. Place the propeller on the front end of the fuselage stick. If the propeller does not fit snugly, wedge small pieces of the balsa wood that you shaved off to tighten.
- 9. Insert pin for the rubber band.
- 10. Align the wings so that the front edge (leading edge) is 1/16" higher than the back edge (trailing edge). Glue into place. Use pins to hold in place while the glue dries. Glue on tail section also using pins to hold in place. See diagram 4.
- 11. To test the plane, wind the rubber band 50-100 times and fly it in an open grassy area away from people.
- 12. If the plane pitches, yaws, or rolls, use what you have learned from the video and adjust your plane.
- 13. Have your own Egg-tra-ordinary plane contest!

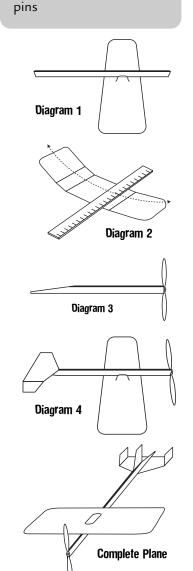
- Conclusion 1. If the plane pitches, what should you adjust on the
 - 2. If the plane yaws, what should you adjust on the plane?
 - 3. What provides the thrust for the plane? How?
 - 4. Why is it important for the wing to have a dihedral
 - 5. Why is it better to use foam egg cartons instead of cardboard egg cartons?

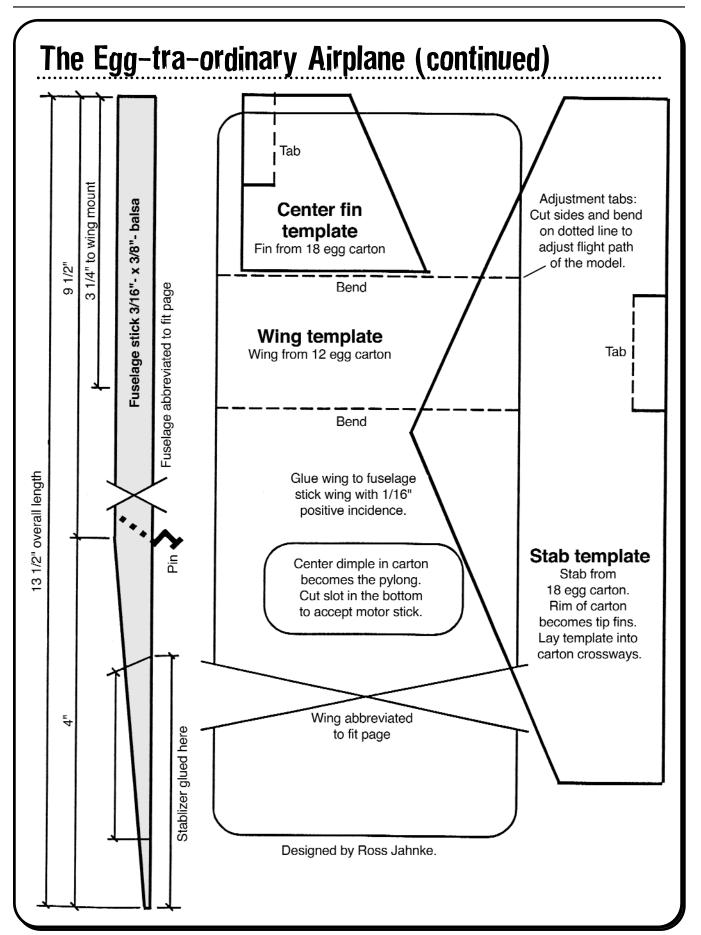
Extensions 1. Experiment to find the relationship between the number of turns of the rubber band and the distance flown. Make a chart and graph to show the relationship.

Materials (per group)

top from a 12-egg carton scissors top from an 18-egg carton needle nose pliers piece of balsa wood (3/8" X 3/16" X 13 1/2") glue razor blade or exact propeller assembly knife 12"-14" long rubber band

ruler



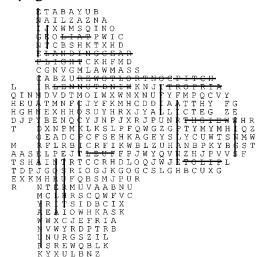


Answer Key

Anatomy of an Airplane

- 1. tail section
- 2. rudder
- 3. elevator
- 4. flaps
- 5. wing
- 6. fuselage
- 7. cockpit
- 8. propeller
- 9. aileron
- 10. spinner
- 11. engine
- 12. landing gear

Flying Word Search



Aileron or No Aileron

- 1.- 4. Answers will vary.
- 5. When the air hits the aileron, it is deflected in the direction the aileron is pointing, causing the air to slow down. The slowing down of the air creates a force that enables the plane to turn or slow down. Think of it in terms of running across a field with your arms outstretched and hitting a light post with your left arm. The force of the pole hitting your arm deflects your body in the opposite direction. The air hitting the aileron also causes the plane to go in the opposite direction, thus enabling a pilot to turn the plane. A pilot will use ailerons to turn the plane, to slow down, to control the pitch, and to land.

Rescue at Sea Game

- 1. Answers will vary.
- 2. In the game, if you needed to move to the right, you should have chosen the spinner whose probability of "thrust" was the highest because "thrust" moved you to the right. You would not have chosen the spinner with a high probability for drag, which would turn you to the left.
- 3. Answers will vary.

The Egg-tra-ordinary Plane

- 1. If the plane pitches up, you should bend the stabilizer tab down. If it pitches down, bend the tab up.
- 2. If the plane yaws to the right or left, bend the rudder tab to the opposite direction.
- 3. The winding of the rubber band provides the thrust for the plane. As you wind the rubber band, you are storing potential energy. When the propeller is released, the energy in the rubber band is released and causes the propeller to turn. As the propeller turns, its shape creates airflow over the propellers, creating a forward force pulling the plane through the air. As the plane is pulled through the air, the air flows over the wings, creating lift.
- 4. It is important for a plane to have a dihedral angle to stabilize the plane as it is turning. The angle gives the pilot more control as he/she turns the plane.
- 5. Foam egg cartons are lighter in weight and will therefore require less thrust to go farther.